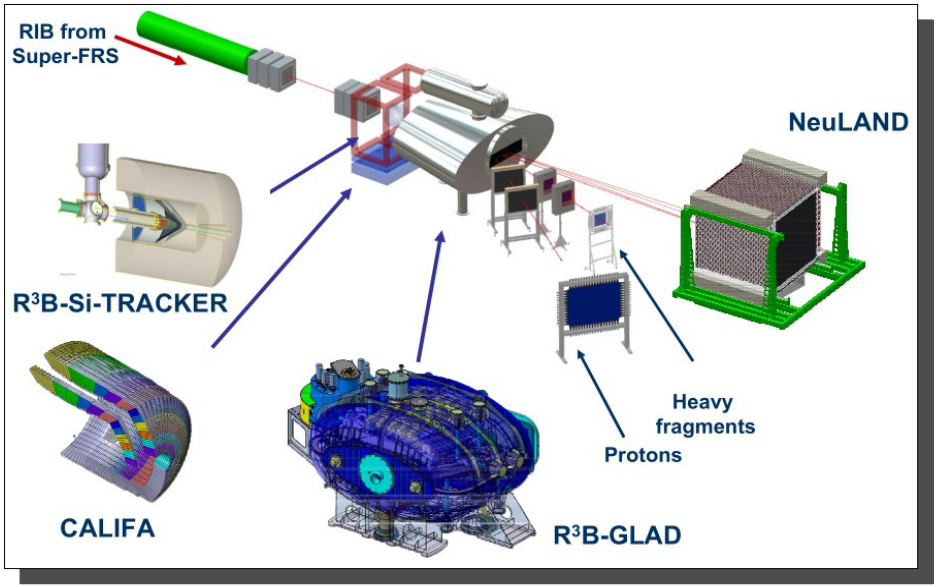
R^3B NeuLAND
Progress at RIBF and GSI

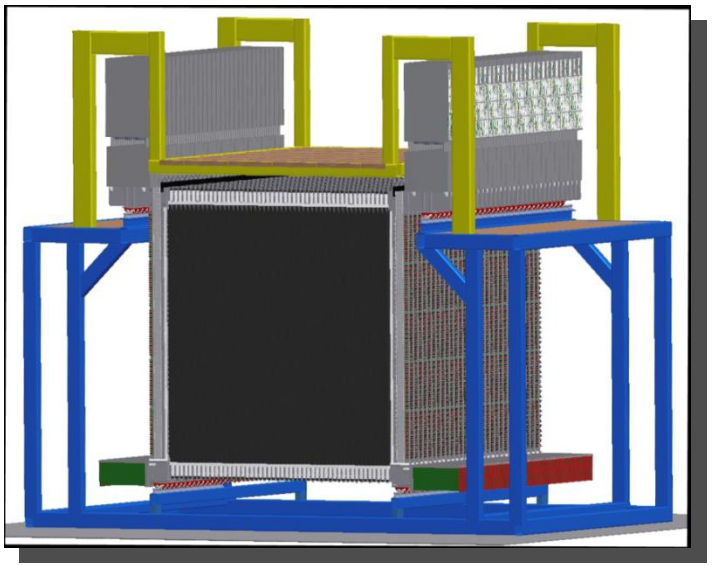
Overview

- NeuLAND
- Development/manufacturing progress at GSI
- RIKEN autumn 2015 commissioning and experiments
- RIKEN accepted proposals

NeuLAND

- NeuLAND = High resolution fast neutron ToF spectrometer for R^{3}B
- Goals:
  - Efficiency 1n: 90% @ ~200MeV, 95% @ – 1.0GeV
  - 60% efficiency for 4n
  - Separation of up to 5 neutrons
- Specs:
  - Fully active plastic detector
  - 3000 scintillator bars, 2.5m x 5cm x 5cm
  - 6000 PMTs
  - Each plane = 50 bars, two crossed planes form a double plane → 30 double planes
  - Double planes act as modules, dedicated readout electronics and HV separable
  - Full WxHxD = 2.5m x 2.5m x 3m





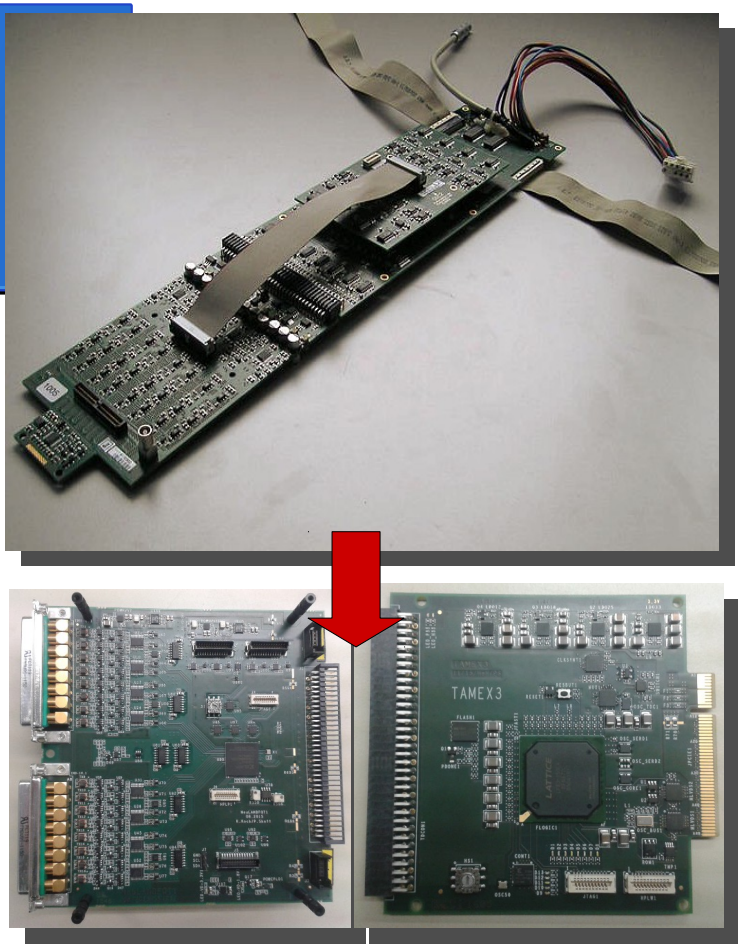
Current status

- Demonstrator variants have been active in several beam times
  - Tacquila + VME and TAMEX1 readout electronics
  - 4 double-plane demonstrator + Tacquila currently in RIKEN

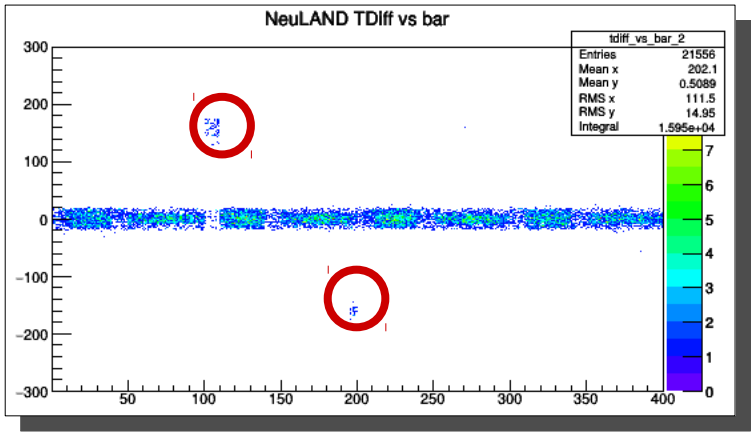
- Construction progressing at GSI
  - Another 4 finished double planes
    → presently 8 in total
  - First support structure for 20 double planes manufactured

- New readout electronics TAMEX3 underway
- New HV distribution system from PNPI

TAMEX



- Replaces Tacquila = ASIC based single-hit TDC
- TAMEX = FPGA based multi-hit TDC
  - 20..150 ps time resolution, depending on amplitude
  - < 1% energy resolution
- Local power regulators
  - Tacquila plagued by global voltage regulation issues
  - Noisy regulators behind copper backplane, one for each card
- 4 PCs for the final 30 double planes
- Fiber readout
  - Tacquila read out with GSI SAM VME modules
- Each PC with TRIXOR card → TRIVA bus → MBS



Last year's cliffhanger: RIKEN

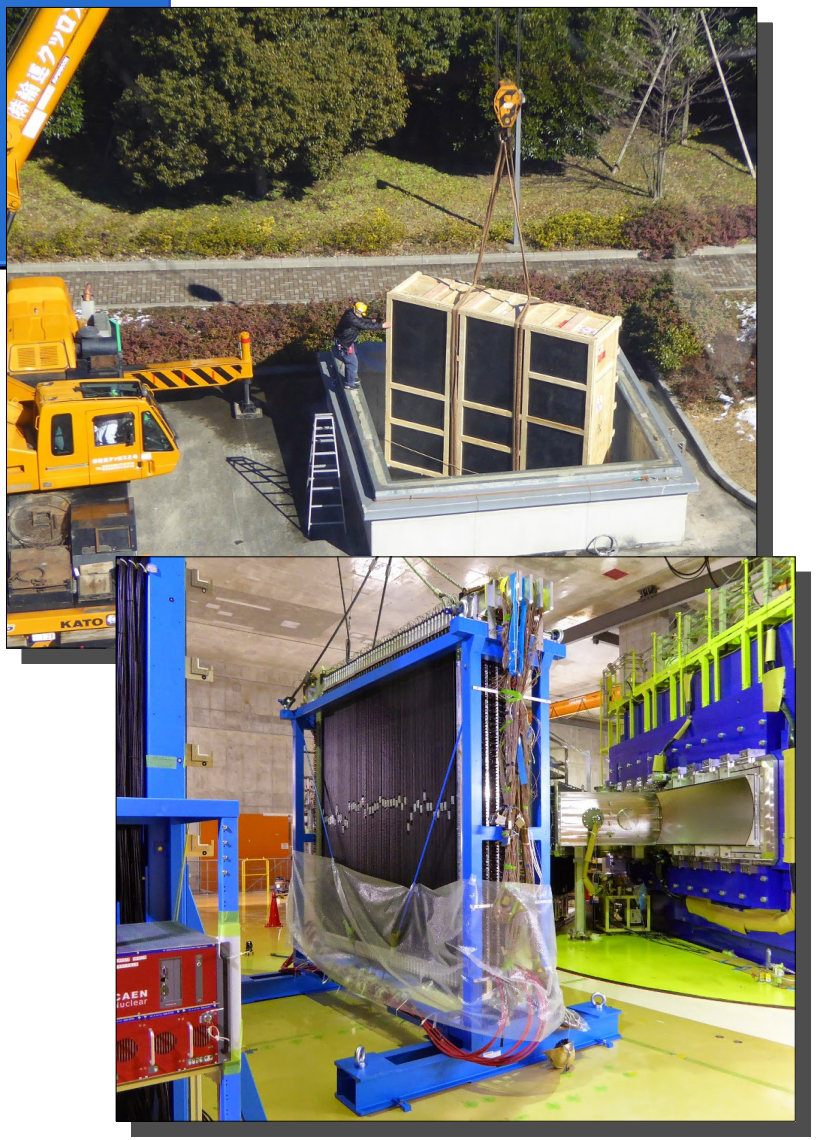
GSI → RIKEN

4 double-planes sent to RIKEN for 2 years

transport box
5.75 tons
401 x 344 x 128 cm^3

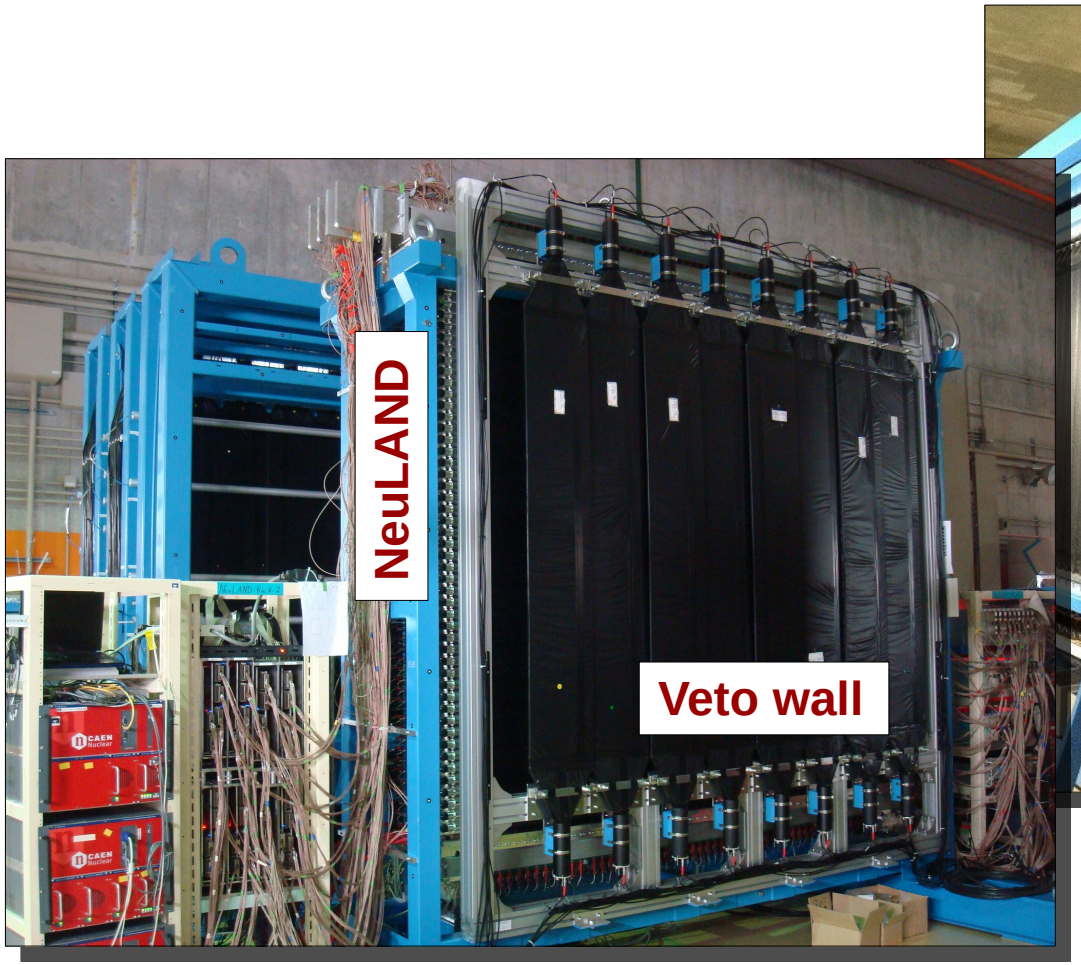
participation in several experiments during 2015 to 2017.

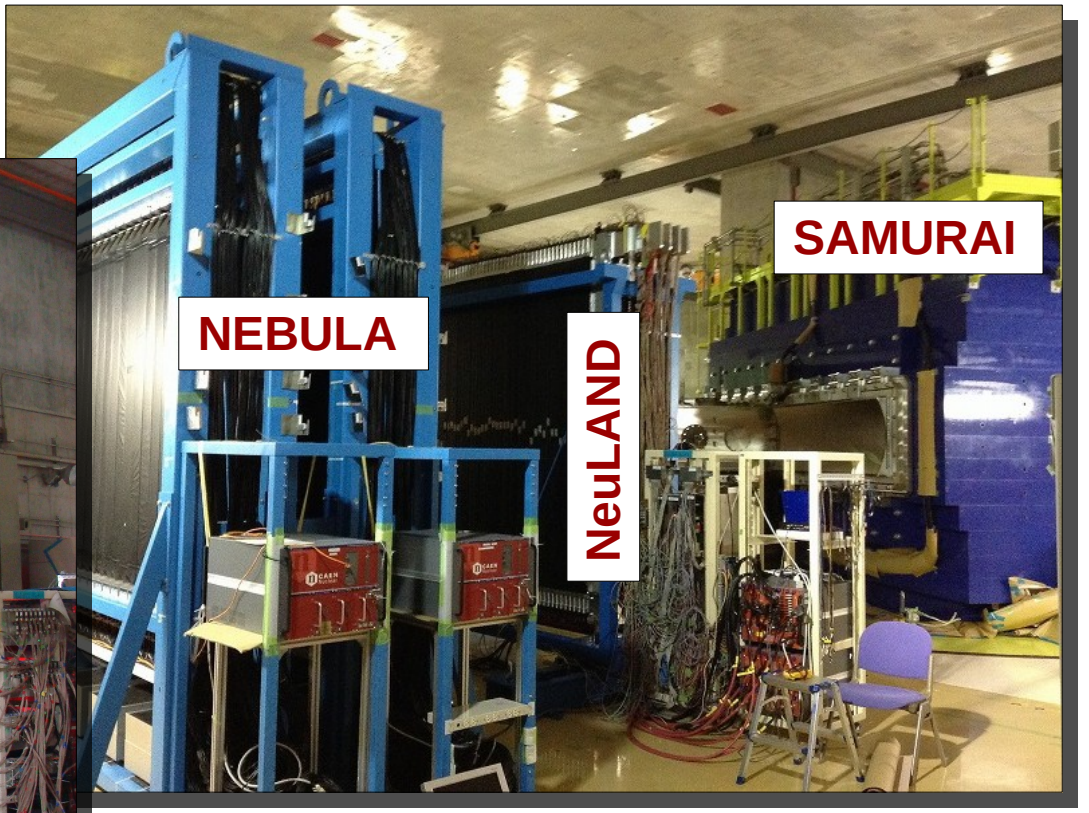
NeuLAND @ RIBF



- NeuLAND at SAMURAI setup, RIKEN 2015-2017
  - Jan: Arrival
  - Feb-Mar: Installation, integration, tests
  - Aug: Experiment preparations
- Two experiments autumn 2015
  - Oct-Nov: ImPACT, nuclear transmutation
  - Nov-Dec: machine study + SAMURAI21

NeuLAND @ RIBF





ImPACT

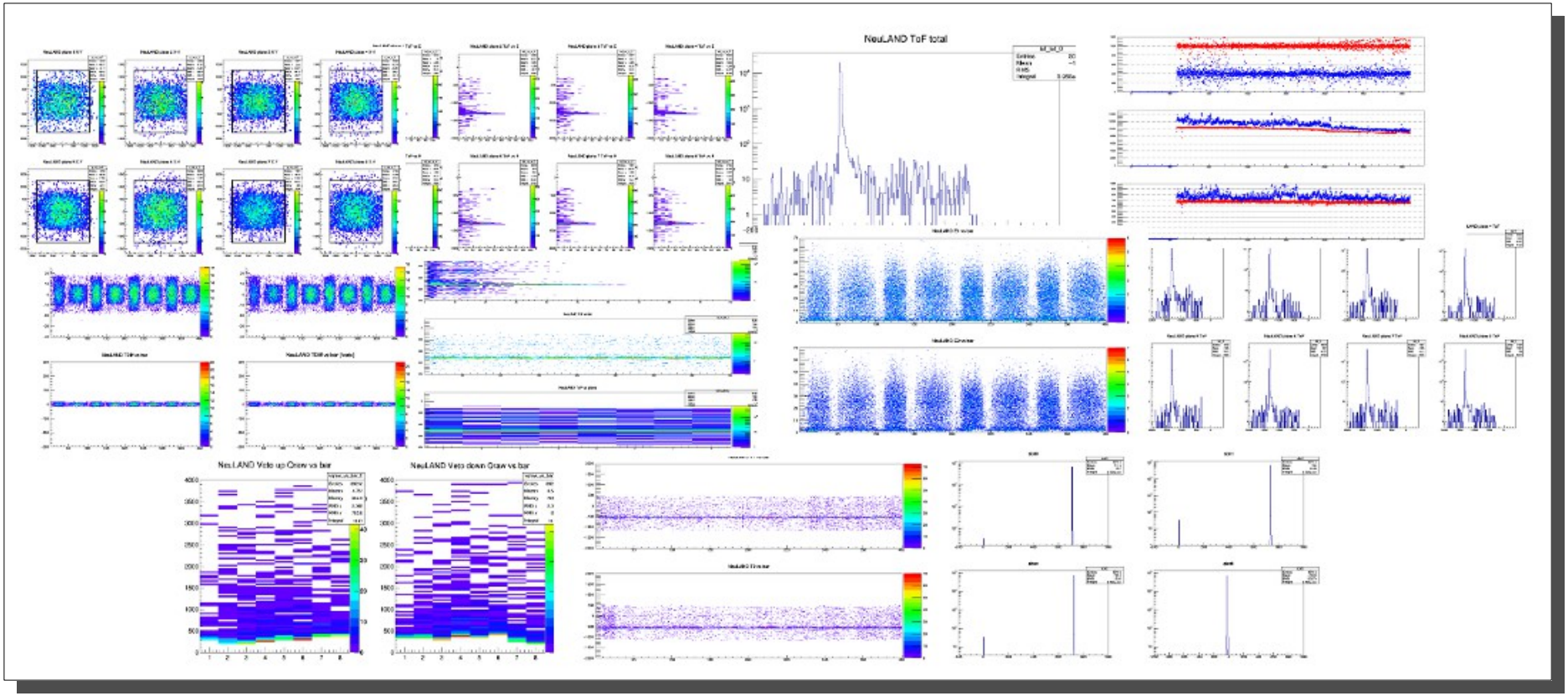
(Impulsing PAradigm Change through disruptive Technologies)

- Collecting data on long lived fission products
- Search for transmutation paths
- NeuLAND contribution: Neutron trigger with NEBULA
- For us: commissioning and preparation

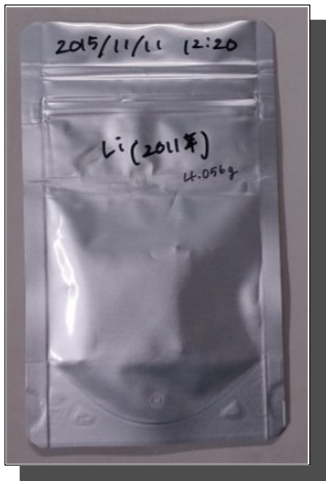
- ✓ Wanted healthy and robust state for machine study and SAMURAI21
- ✓ DAQ trial: NeuLAND MBS ↔ SAMURAI RIBFDAQ
- ✓ Initial iteration of analysis/monitoring tools with RIBF ANAROOT analysis framework developed and tested

Online monitor

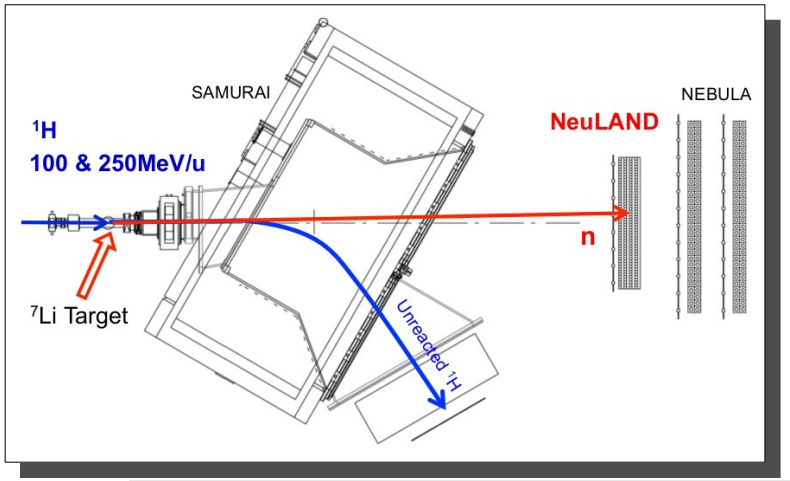
- Based on nearline histograms from GSI
- Clients adjusted to server configuration on-the-fly
- Snapshot dump to file for easy e-log:ing

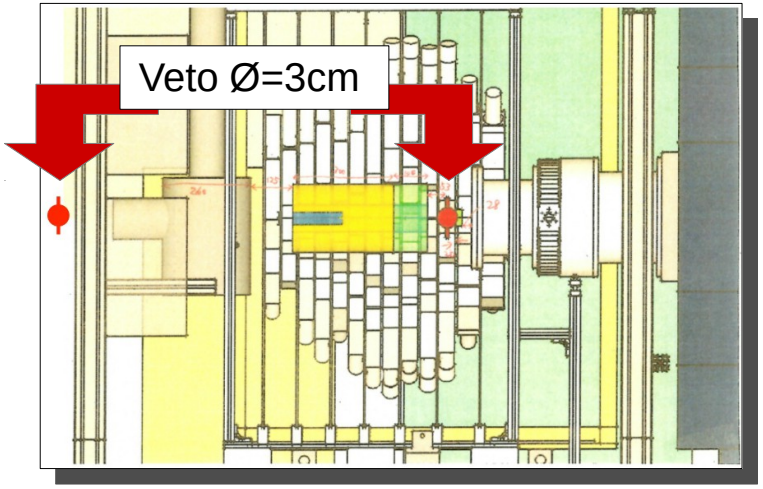


Machine study



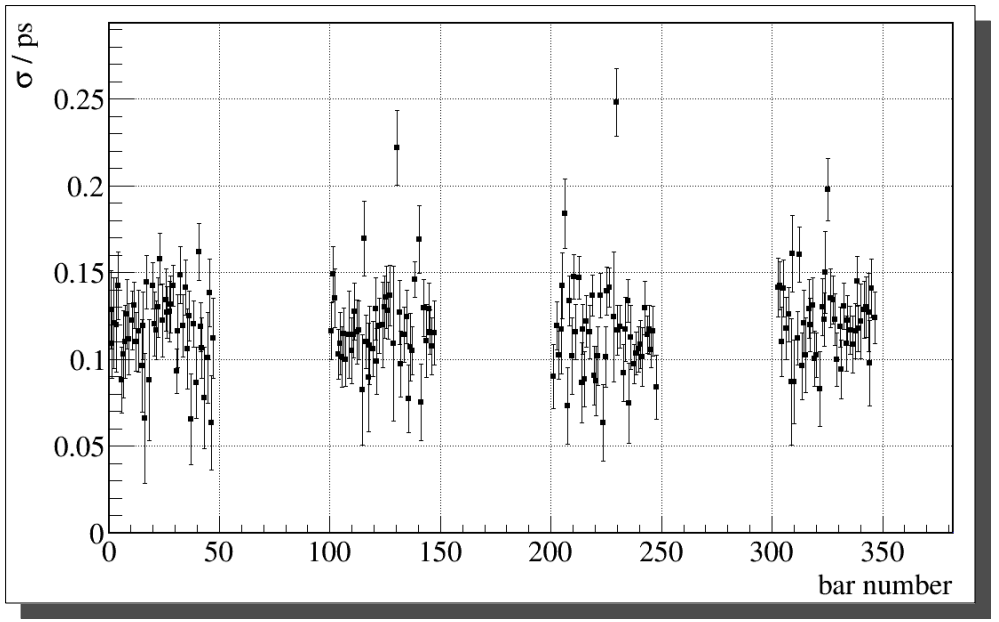
- ^{7}Li(p,n)^{7}Be @ 110 MeV and 250 MeV
  - Used for both NEBULA and NeuLAND calibration
  - Quasi-monoenergetic neutron source with leading tail
  - 1Mhz proton beam, 1.5kHz Beam x NeuLAND
- For performance evaluation
  - 1n efficiency
  - Data for multi-neutron identification developments





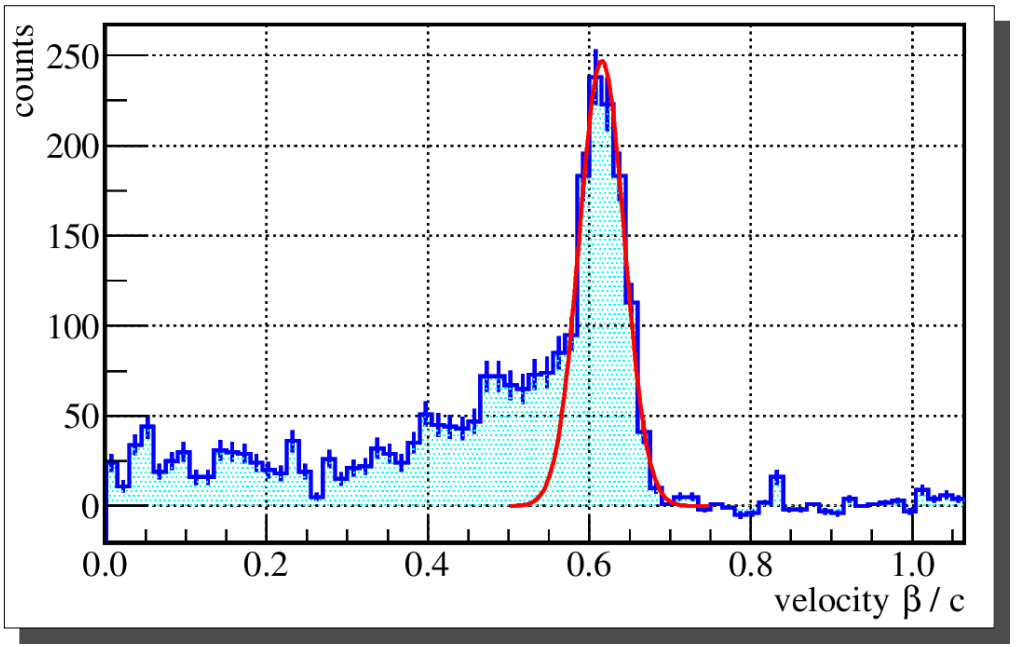
Machine study
Preliminary results

Analysis by J. Kahlbow,
IKP TU Darmstadt



Cosmic ray time resolution = 118±18 ps,
comparable to GSI

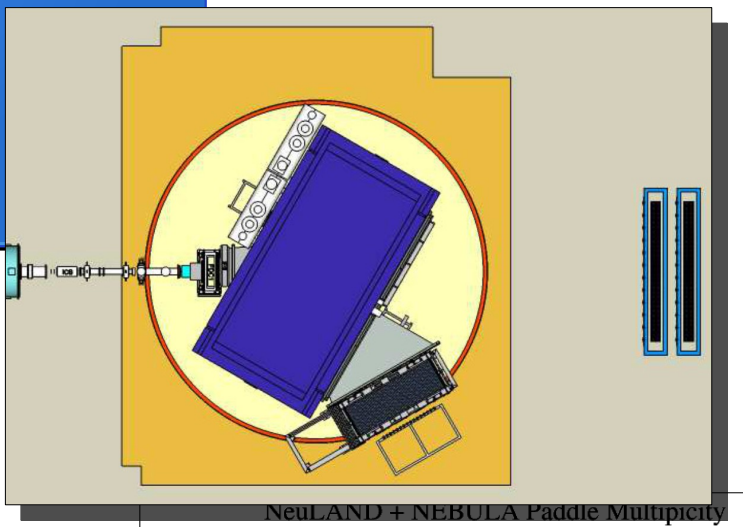
n det. eff.:
38.5±1.6% @ 250 MeV
35.8±1.5% @ 110 MeV



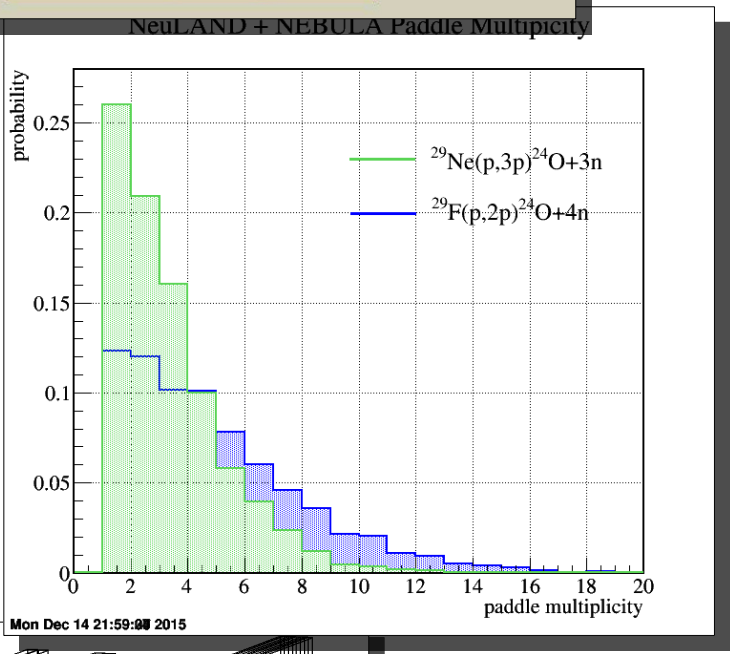
Prognosis: Results in May 2016

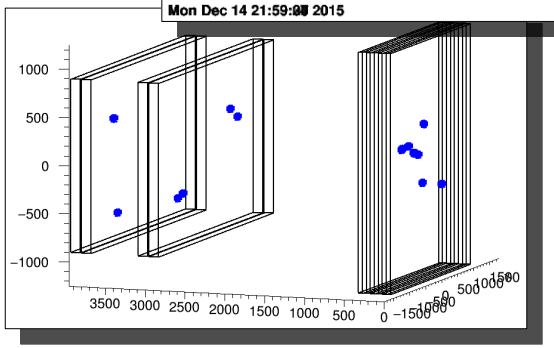
SAMURAI21

Spokesperson Y. Kondo (TiTech)

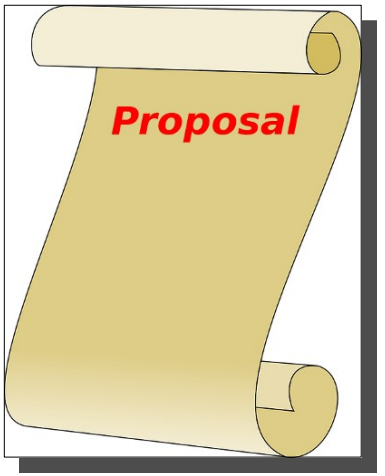


- Oxygen isotopes at the neutron dripline
  - ^{29}Ne(p,3p)^{27}**O**+3n
  - ^{29}F(p,2p)^{28}**O**+4n
  - And also ^{29}Ne(p,2p)^{28}**F**
- People curious about this region
  - Kink on the neutron-rich side
  - Rapid shell structure changes in the vicinity
- High neutron detection efficiency requirement
  - NeuLAND collaborated with NEBULA
- Analysis on-going
  - Incoming & outgoing ID + fragment arm ok
  - In-depth neutron analysis pending
  - Next meeting on the 16th of March





On the RIKEN horizon

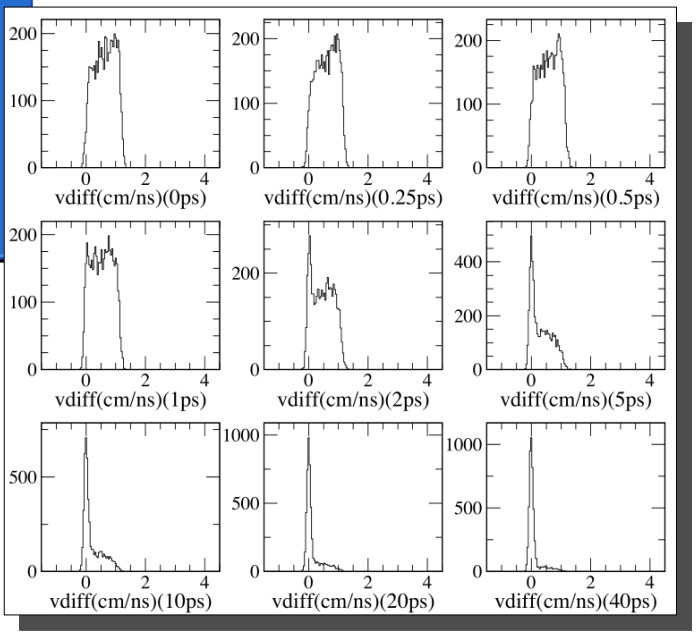


- In May: Equation of state
  - Stricter limits on nuclear symmetry energy
- Accepted group proposals, not yet scheduled:
  - Caesar: ^{26}O g.s. lifetime
  - Paschalis (Rossi) & Shimoura: ^{8}He(p,pα)4n
  - Aumann & Nakamura: Dipole response
    - ^{6,8}He, ^{24}O, ^{29}F

Equation of state

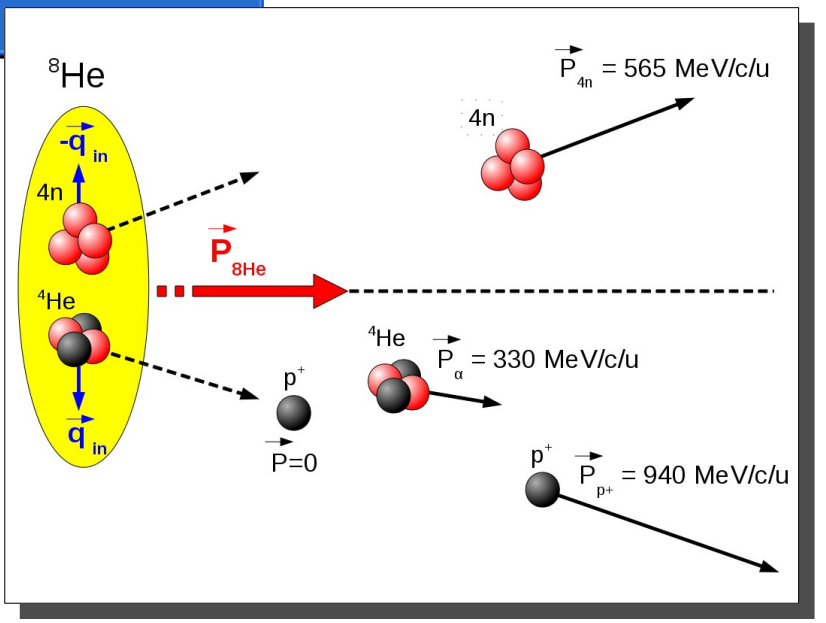
- Pinning down the density-dependent symmetry energy
  - RIBF energies → $\rho/\rho_0 \approx 2$
- Several ways to go
  - pion +/- ratio, p/n ratio, ...
- TPC for charged particle tracks, will go inside SAMURAI
- Hmm, neutrons, how do we detect them…
- Enhanced detection efficiency of NeuLAND+NEBULA again important

Caesar: 26O g.s. lifetime



- Experiments suggest very short lived g.s.
  - 2n decay?
- Exp. (MSU) $T_{1/2}$=6.5 ps → theory 1 keV…
  - $T_{1/2}$ with large uncertainty, reliant on good conditions to extract peak shift from ToF differences
- Reduce dependency on absolute velocity calibration
  - Optimized in the few ps range, down to 1 ps possible
- Good time resolution from NeuLAND + NEBULA

Paschalis & Shimoura: 4n



- 8He(p,pα)4n
  - Charged particles allows 4n reconstruction
  - NeuLAND + NEBULA to investigate the decay
  - 2n to find n-n correlations
  - 3n to be kinematically complete
- Similar: Kisamori, 8He(p,2p)7H → t + 4n
  - Search for narrow 7H ground state + 4n
  - 4n reconstruction for 7H, NeuLAND + NEBULA essential

Aumann & Nakamura: Dipole response

- ^{6}He: no high energy data available
  - Only up to first photo-absorption peak
- ^{8}He: only low-lying 2n decay fully identified
  - No exp. data for theory after 4n kicks in
  - Invariant mass → all 4n needed
- ^{24}O and ^{29}F
  - Dipole response measured for the first time
- All candidates for pygmy resonances

To conclude

- Production and development going strong at GSI
- More than 1/3 of NeuLAND will be ready for GSI beam beginning of 2018
- Successful integration and runs at RIBF
- Several in-group accepted proposals ready

Towards the FAIR proving grounds!